Comparison of laser-based and conventional calibrations of sun photometers

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ABSTRACT

Sun photometers are used to characterize the radiative properties of the atmosphere. They measure both the incident solar irradiance as well as the sky radiance (from scattered incident flux). Global networks of sun photometers provide data products such as aerosol optical thickness derived from these measurements. Instruments are typically calibrated for irradiance responsivity by cross-calibration against a primary reference sun photometer and for radiance responsivity using a lamp-illuminated integrating sphere source. A laser-based facility for Spectral Irradiance and Radiance Responsivity Calibrations using Uniform Sources (SIRCUS) has been developed at the National Institute of Standards and Technology. Sensors can be calibrated in this facility for absolute spectral irradiance and radiance responsivity with combined expanded (k = 2) uncertainties ranging from 0.15 % to 0.25 %. Two multi-channel filter radiometers used in the Sensor Intercomparison and Merger for Biological and Interdisciplinary Oceanic Studies (SIMBIOS) program of the National Aeronautics and Space Administration (NASA) at the Goddard Space Flight Center (GSFC) were calibrated for radiance and irradiance responsivity using conventional approaches and using laser-illuminated integrating spheres on SIRCUS. The different calibration methods are compared, the uncertainties are evaluated, and the impact on remote sensing applications is discussed.

Keywords: Calibration, irradiance, radiance, responsivity, solar irradiance, sun photometer

1. INTRODUCTION

Ground-based measurements of the direct solar irradiance and the diffusely scattered solar radiance have been widely used to characterize the optical properties of the atmosphere and derive information about the composition and distribution of aerosols. More recently, global aerosol distributions have been measured remotely using satellite-borne sensors. The information derived from these measurements is used for aerosol research and radiative transfer modeling as required for global climate change studies. In satellite-based ocean color remote sensing measurements, approximately 90 % of the signal measured at the satellite sensor comes from atmospheric scattering. Proper atmospheric characterization and aerosol modeling is necessary to separate the atmospheric component from the top-of-the-atmosphere radiance, required for valid satellite-based measurements of ocean color data products such as global, near-surface, phytoplankton chlorophyll-*a* distributions.

Sun photometers and sky radiometers are used to characterize the optical properties of the atmosphere. Measurements are used to validate remote sensing aerosol optical thickness retrievals, evaluate current aerosol models and in the development of vicarious sensor calibration methodologies [1]. Networks of sun photometers are distributed globally through the National Aeronautics and Space Administration's (NASA's) Aerosol Robotic Network (AERONET) [2], NASA's Sensor Intercomparison and Merger for Biological and Interdisciplinary Oceanic Studies (SIMBIOS) Project [3] and the World Radiation Center (WRC), Davos, Switzerland [4]. Sun photometers make measurements of the direct solar irradiance as well as the sky radiance. These are distinct radiometric measurements and instruments are typically calibrated for both irradiance and radiance responsivity.

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